

**FORMATION OF PRE-IMPACT, INTERSTITIAL CARBONATES IN THE ALH84001 MARTIAN METEORITE.** E. R. D. Scott and A. N. Krot, Hawai'i Institute of Geophysics and Planetology, School of Ocean and Earth Science and Technology, University of Hawai'i at Manoa, Honolulu HI 96822 (escott@pgd.hawaii.edu).

We have argued that the existing carbonates in fractures in ALH84001 were derived from impact melts [1,2]. The morphology and distribution of carbonate and plagioclase glass in the fracture zones precludes formation of the existing carbonates in vugs or by replacement of plagioclase glass. We infer that carbonates in fractures and fracture zones were derived from preexisting carbonates that were located at interstitial sites closely associated with plagioclase, along with minor chromite and traces of silica, phosphate and orthoclase. Since plagioclase was entirely melted by shock [3], the adjacent phases must have experienced high post-shock temperatures and shock pressures of ~40 GPa. Thus impact may have drastically changed the abundance and composition of the interstitial minerals in ALH84001: for example, carbonates, sulfates, and clay minerals may have partly decomposed, as in shergottites, which are also heavily shocked [4]. In ALH84001, magnetites probably formed during impact by partial decomposition of siderite [5] and trace amounts of olivine appear to have formed around carbonate nodules [6] in fractures. However, the relatively small amounts of olivine and magnetite suggest that these reactions did not cause drastic changes in the major-element bulk composition of the carbonate.

We consider four possible origins for the interstitial carbonates that we infer to have existed in ALH84001 prior to impact; 1) crystallization from residual igneous melts, 2) reaction of plagioclase with metasomatic magmatic fluids that percolated along grain boundaries, 3) hydrothermal replacement of plagioclase, and 4) low-temperature precipitation from aqueous solutions in vugs. All four models have problems. High temperature formation would account for the similarity in mean Mg/(Mg+Fe) of carbonates and pyroxene, and might be favored by the similarity of  $\delta^{18}\text{O}$  of pyroxene and dolomite [7]. However, the difference in  $\Delta^{17}\text{O}$  between carbonate and Martian meteorite whole rock values [8] shows that the existing carbonates could not have formed from a purely magmatic source and must have formed from a

source that acquired an atmospheric O component. This favors a near surface origin for the pre-existing carbonates though the atmospheric component could have been acquired by magmatic carbonates during impact. Another argument against a magmatic origin is the high pressure required to prevent carbonate and pyroxene from reacting to form  $\text{CO}_2$ : at 900 °C pressures of >1.5 GPa and burial depths of ~120 km would be needed [9]. Excavation of ALH84001 from such depths after cooling seems less plausible. The probable existence of Martian atmosphere in ALH84001 [10] appears to require a near-surface location at the time of shock melting.

Although most authors favor a low-temperature origin for the carbonates and salts in other Martian meteorites [4], high-temperature processes have also been proposed for Zagami [11] and Nakhla [12]. Low-temperature formation as evaporite deposits [13, 14] would be consistent with evidence for episodic and brief infiltrations of water in Lafayette [15] and Chassigny [16], the absence or lack of silicate alteration in Martian meteorites [4, 14-16], and photogeologic evidence for episodic flows of water on Mars, even on recent lava flows [17].

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